Simulation of Blast and Behind-Armor Blunt Trauma to Life-Critical Organs in the Human Torso

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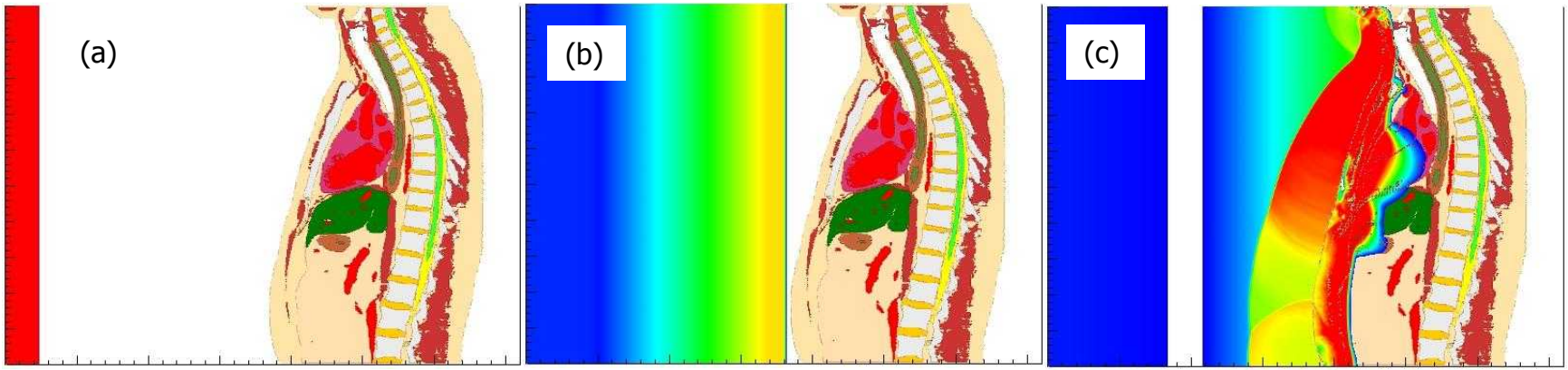
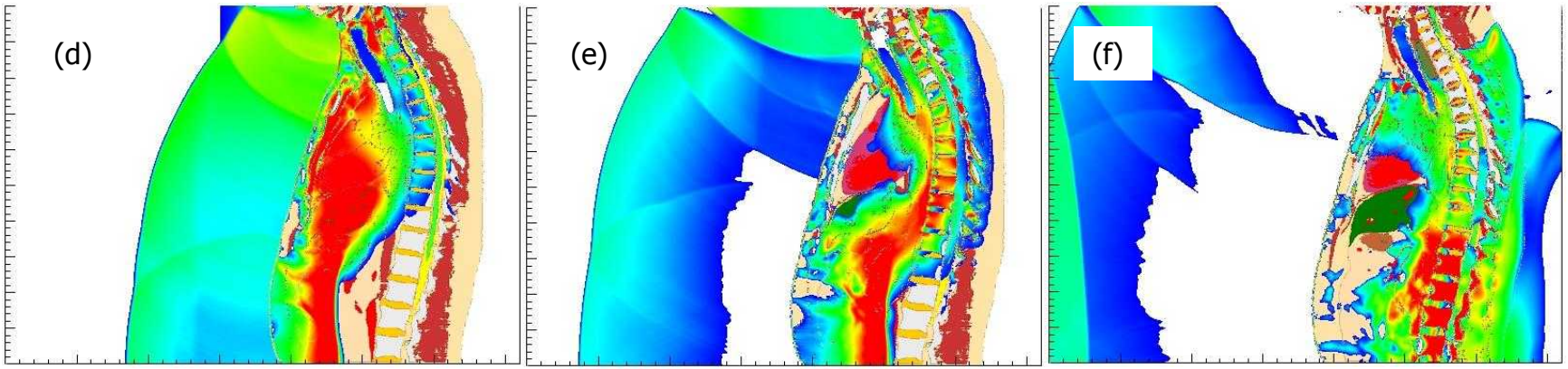
Researchers at Sandia National Laboratories have developed a high-fidelity virtual model of the human torso to investigate the details of life-threatening injury to the respiratory and cardiovascular systems as a result of blast exposure and behind-armor blunt trauma. This model is an extension of the Sandia virtual head-neck model developed previously to investigate the connection between blast exposure and traumatic brain injury. The Sandia human torso model possesses anatomically correct distributions of bone, cartilage, intervertebral disks, vasculature, blood, airways, lungs, heart, liver, stomach, kidneys, spleen, spinal cord, muscle, and fat/skin. The torso model is used with the Sandia wave physics code CTH to simulate blast loading and ballistic projectile impact to the torso, without and with protective armor, to investigate the details of injury to life-critical organs such as the lungs, airways, heart, blood vessels, and liver as a result of the intrathoracic pressure waves that are generated from a blast or impact. The intent of this work is to demonstrate the advantages of applying a modeling and simulation approach to the investigation of wound injury dynamics and to assess protective body armor for the U.S. warfighter under conditions of blast and ballistic projectile impact. A typical torso injury scenario simulation requires anywhere from 448 to 896 cpu-cores, running the calculation for 30 to 60 cpu-hours, and generating over 500 Gb of raw data that is post-processed at a later time for injury investigation and/or protective armor assessment.





Frontal blast wave exposure of Sandia Human Torso Model. (a) Initial setup. Blast wave is generated from reservoir (denoted in red) of high pressure air on left side of image. (b) Blast wave propagating to right with wave front just prior to contact with torso. (c) Blast wave has generated transmitted pressure wave into thorax and reflected air wave traveling back towards blast source. (d)-(f) Time-evolution of wave transmission within thorax and reflected wave in air. White space outside torso indicates regions experiencing pressures below 1 atmosphere in magnitude.